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(54) Method and installation for conditioning the atmosphere in storage chamber for organic harvested produce.

(57) The invention relates to a method for conditioning the atmosphere in a storage chamber for organic harvested produce, characterised in that the storage chamber is allowed to form part of a system composed of the relevant storage chamber (1), at least two, and preferably three, gas separation modules (2), (3) and (4), which are located downstream of one another and are provided with N_2/O_2 separation membranes, at least one compressor (5) and at least one control valve (6),

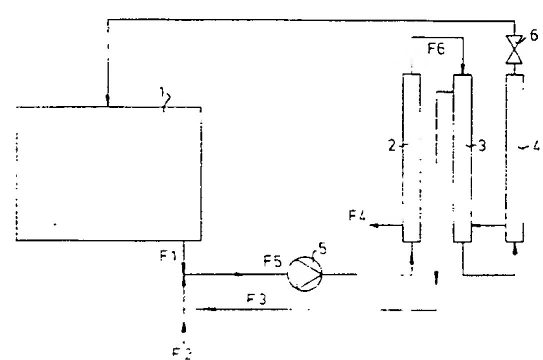
— the compressor drawing in three streams (F1), (F2) and (F3),

— the first separation module yielding a permeate, which is removed from the system as stream (F4), and a retentate, which is fed to the second separation module,

— the second separation module yielding a retentate, which is fed to the third separation module, and a permeate, which is fed together with the permeate from the third separation module as stream to the compressor, and

— the retentate from the third separation module is fed via the control valve to the storage chamber.

Fig-1



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The invention relates to a method and an installation for conditioning the atmosphere in a storage chamber or storage cell for organic harvested produce, such as apples, pears, potatoes, flowers, cer als and the like.

INTRODUCTION

For all storage methods relating to organic harvested produce it is considered essential that the loss in quality of the stored products in question is kept as low as possible during storage. Therefore, it is important that ageing, microbiological or physiological decay, loss of moisture and damage to the stored product in question are prevented as far as possible. In order to achieve the abovementioned aim, methods which relate to conditioning of the atmosphere in the chamber in which the harvested produce is stored are disclosed in the prior art. One of these methods for conditioning the atmosphere in a storage chamber comprises flushing the storage chamber with nitrogen, by which means the oxygen is driven out of the storage chamber. However, this method has the disadvantage that, as a result of the lack of oxygen in the atmosphere, anaerobic bacteria can become active, as a result of which the quality of the stored product can be drastically reduced. For example, in the case of apples fermentation occurs, which leads to a product unacceptable to the consumer. Another storage method comprises cooling the organic produce stored in the storage chamber. This method generally has the disadvantage that the storage time is relatively short. In the case of apples this is only 2 to 3 months, after which the quality decreases to an unacceptable degree. Yet another method for conditioning the atmosphere in such storage chambers comprises lowering the oxygen content and, at the same time, raising the carbon dioxide content in the atmosphere prevailing in these chambers. However, this method entails the risk of the occurrence of the "CO_2 disease", as a result of which, once again, the quality of the stored product is lost.

It has been found that the disadvantages of the abovementioned known methods can be overcome if the storage chamber is allowed to form part of the system composed of the relevant storage chamber (1), at least two, and preferably three, gas separation modules (2), (3) and (4), which are located downstream of one another and are provided with N_2/O_2 separation membranes, at least one compressor (5) and at least one control valve (6),

- the compressor (5) drawing in three streams, i.e.
  - (a) a stream (F1) which is drawn in from the storage chamber;
  - (b) a quantity of outside air (F2) and
  - (c) a recycle stream (F3), which is a combination of the permeate streams from the last two separation modules (3) and (4);
- the first separation module (2) yielding a permeate, which is removed from the system as stream (F4), and oxygen and carbon dioxide are thereby removed from the system until the oxygen concentration of the stream (F4) has reached the equilibrium value (21% by volume), and a retentate, which is fed to the second separation module (3),
- the second separation module (3) yielding a retentate, which is fed to the third separation module (4) - if this is present -, and a permeate, which is fed together with the permeate from the third separation module (4) as stream (F3) to the compressor (5), and
- the retentate from the third separation module (4) being fed via a control valve (6) to the storage chamber (1).

More particularly, at the start of the conditioning, according to the invention, of the atmosphere in the storage chamber (1) the oxygen concentration of stream (F1), which is drawn into the compressor (5), will be about 21% by volume (approximately equal to the oxygen concentration of the outside air). In this initial phase, the recycle stream (F3) produces an increase in the oxygen concentration of the feed to the compressor. The effect of the first separation module (2) with respect to oxygen removal is appreciably improved by this means. Oxygen removal from the first module (2) is determined by two factors, i.e. (a) the incoming oxygen concentration and (b) the flow rate, i.e. the air factor. A high flow rate results in an increase in the oxygen concentration which escapes as permeate. This oxygen-enriched air stream is indicated in Fig. 1 as stream (F4). The oxygen concentration of this air stream will be at 46% at the start of conditioning and gradually become lower during conditioning, depending on the concentration (F1). The amount which is separated off as oxygen-enriched permeate is equal to the quantity of outside air which the compressor (5) draws in as stream (F2). The storage chamber (1) will reach the lowest oxygen content when the oxygen concentration of the stream (F4) is equal to the oxygen concentration of the ambient air. As thē quantity flowing through this module is large, this will be the case only when the O_2 concentration of the atmosphere in the storage chamber is low. Modules (3) and (4) produce a further lowering in the oxygen concentration of the retentate stream (F6) which leaves module (2). The outgoing O_2 concentration of the membrane unit stream is determined by the residence time or flow rate and this can be adjusted by means of a needle valve (6). The O_2 concentration obtained downstream

of the last module in the stream which passes to the storage chamber (1) will fall depending on the O_2 concentration of the atmosphere in the storage chamber (1), while the quantity increases somewhat because the pressure in the system rises. Permeat stream (F3) provides an oxygen loop, which ensures that the O_2 concentration in the permeate from the first module remains high. By this means, the final value for the O_2 concentration in the atmosphere in the storage chamber is obtained at a low concentration. As a result of the recycling through the storage chamber and specifically as a result of the oxygen loop (F3), the time in which a storage chamber can be conditioned can be appreciably shortened.

What has been described above in respect of the oxygen concentration also applies in principle with respect to the carbon dioxide concentration in the atmosphere in the storage chamber (1). In this case also the major proportion of the CO_2 present is separated off via the first module (2). In addition, the difference compared with oxygen is that the separation factor for carbon dioxide versus nitrogen is appreciably higher than that for oxygen versus nitrogen, as a result of which the carbon dioxide concentration which leaves the membrane unit and passes to the storage chamber will be very low. The concentration of carbon dioxide which is present in the ambient air and is drawn in by the compressor (F2) is only 0.05%. Consequently, it is possible to obtain a virtually carbon dioxide-free storage chamber. Specifically, this CO_2 removal is virtually independent of the membrane setting.

By changing the membrane setting it is possible to obtain any desired oxygen concentration in the storage chamber (1), while the installation continues to remove carbon dioxide.

Advantageously, the O_2 content of the atmosphere in the storage chamber is brought to a value of less than 5% by volume, preferably to a value in the range from 1 to 2% by volume or of 0.5 to 1% by volume.

Membranes which can be used as the N_2/O_2 gas separation membranes to be used in the invention are all membranes disclosed in the prior art. Examples of such membranes are the Prism Alpha membrane (Permea Inc. St. Louis, USA), the Generon membrane (Linde division Union Carbide Industrial Gases) and the poly(2,6-dimethyl-p-phenylene oxide) asymmetric hollow fibre membranes (EP-B-0,298,531).

LEGEND

Fig. 1: shows, diagrammatically, a system according to the invention comprising:
- a storage chamber (1)
- three separation modules (2), (3) and (4), which are located downstream of one another and are provided with a N_2/O_2 separation membrane,
- a compressor (5) and
- a control valve (6), which components are connected to one another via the indicated lines.

Fig. 2: shows a graph of the test results relating to CO_2 removal in a storage chamber which has a free space of 225 m^3. The CO_2 concentration of the atmosphere in the storage chamber in % by volume is shown on the ordinate and the time in hours is shown on the abscissa.

Fig. 3: shows a graph of the test results relating to O_2 removal in a storage chamber which has a free space of 225 m^3. The O_2 concentration of the atmosphere in the storage chamber in % by volume is shown on the ordinate and the time in hours is shown on the abscissa.

ILLUSTRATIVE EMBODIMENT

A flow of 18,500 l/hour (F1) was withdrawn via a compressor (5) from a storage chamber (1), which was filled with 60 tonnes of apples and still had a free space of 225 m^3. This compressor (5) drew in 13,800 l/hour of air via the outside air. The stream (F3), which originated from the second (3) and third (4) gas separation module, was 23,300 l/hour. The gas stream issuing from the compressor (5) was fed at a flow-through volume of 0. 72 l into the first gas separation module (2), which was provided with a PPO membrane (poly (2,6-dimethyl-p-phenylene oxide) asymmetric hollow fibre membrane, skin thickness = 0.2 μm; see EP-B- 0,298,531) having a surface area of 13 m^2. The retentate from this first module was fed at a flow-through volume of 0. 72 l into the second gas separation module (3), which was provided with a PPO membrane (see above definition) having a surface area of 13 m^2. The retentate from the second module was then fed at a flow-through volume of 0.72 l into the third module (4), which, in turn, was provided with a PPO membrane (see above definition) having a surface area of 13 m^2. The retentate from this third module was returned via the needle valve (6) to the storage chamber (1).

The results relating to the atmosphere in the storage chamber (1), which were obtained at ambient temperature (20°C), are shown in Table A below (and also in Figs. 2 and 3).

TABLE A

TIME (HOURS)	MEASURED CONC. O_2	MEASURED CONC. CO_2
0	18.1	4
1		
2	15.8	
3	14.8	3.2
4	13.8	
5	12.9	
6	12	2.9
7	11.1	
8	10.3	
9	9.6	
10	8.9	2.6
11	8.2	
12	7.8	
13	7.1	
14	6.7	
15	6.1	
16	5.8	2.2
17	5.5	
18	5.1	
19	4.9	
20	4.5	1.8
21	4.2	
22	3.9	

Claims

1. A method for conditioning the atmosphere in a storage chamber for organic harvested produce, characterised in that the storage chamber is allowed to form part of the system composed of the relevant storage chamber (1), at least two, and preferably three, gas separation modules (2), (3) and (4), which are located downstream of one another and are provided with N_2/O_2 separation membranes, at least one compressor (5) and at least one control valve (6),
   - the compressor (5) drawing in three streams, i.e.
     (a) a stream (F1) which is drawn in from the storage chamber;
     (b) a quantity of outside air (F2) and
     (c) a recycle stream (F3), which is a combination of the permeate streams from the last two separation modules (3) and (4);
   - the first separation module (2) yielding a permeate, which is removed from the system as stream (F4) and a retentate, which is fed to the second separation module (3),
   - the second separation module (3) yielding a retentate, which is fed to the third separation module (4), and a permeate, which is fed together with the permeate from the third separation module (4) as strew (F3) to the compressor (5), and

- the retentate from the third separation module (4) being fed via a control valve (6) to the storage chamber (1).

2. Method according to Claim 1, characterised in that the O_2 content in the atmosphere in the storage chamber is brought to, and maintained at, a value of less than 5 % by volume.

3. Method according to Claim 1 or 2, characterised in that the O_2 content in the atmosphere in the storage chamber is brought to, and maintained at, a value in the range from 1 to 2% by volume.

4. Method according to Claim 1 or 2, characterised in that the O_2 content in the atmosphere in the storage chamber is brought to, and maintained at, a value in the range from 0.5 to 1% by volume.

5. Installation suitable for conditioning the atmosphere in a storage chamber for organic harvested produce, characterised by
   - a storage chamber (1) for the organic harvested produce,
   - at least two, and preferably three, separation modules (2), (3) and (4), which are connected downstream of one another and are provided with an N_2/O_2 separation membrane,
   - at least one compressor (5) and
   - at least one control valve (6), the components of the installation being connected to one another via lines as shown in Fig. 1.

Fig-1

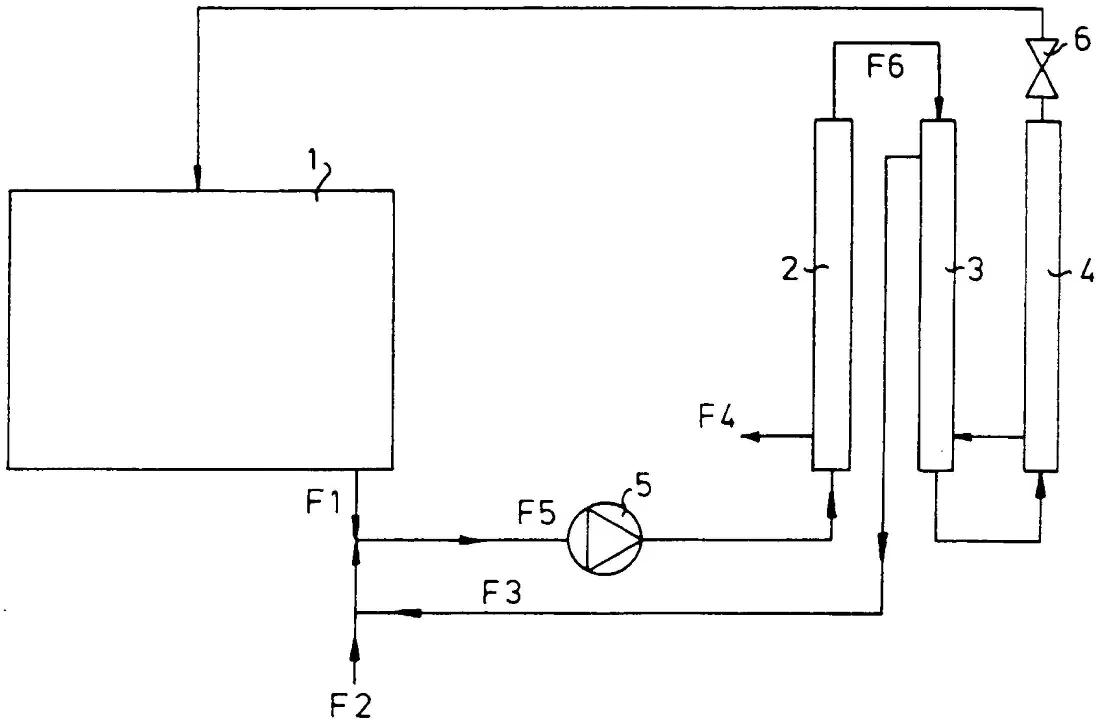

1
2
3
4
5
6
F1
F2
F3
F4
F5
F6

Fig-2

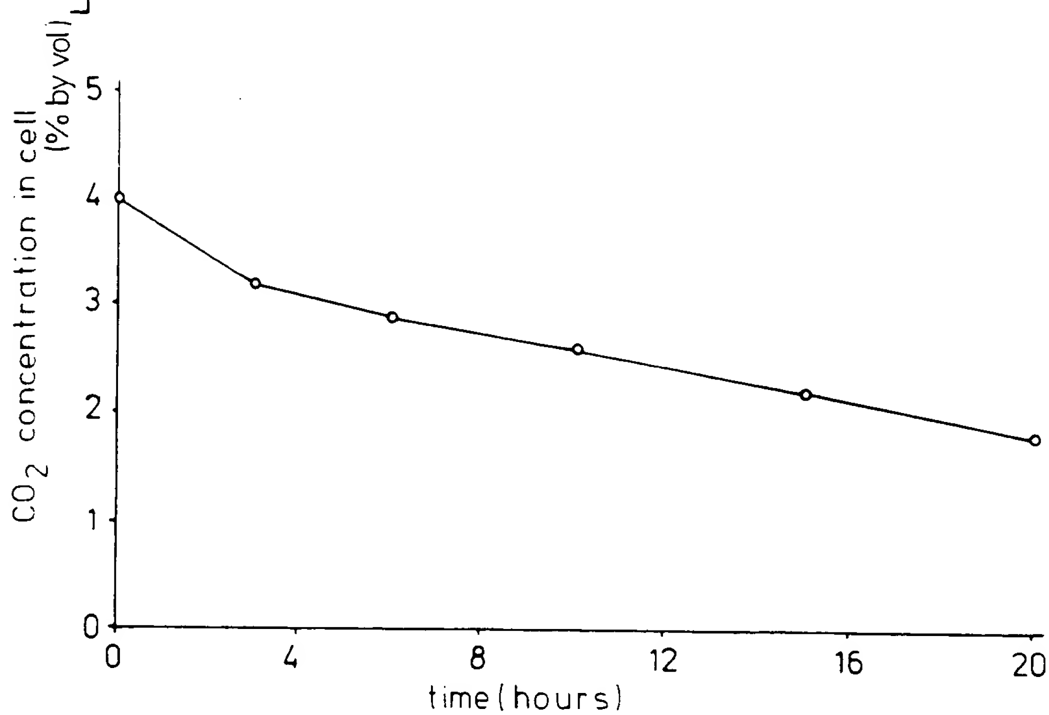
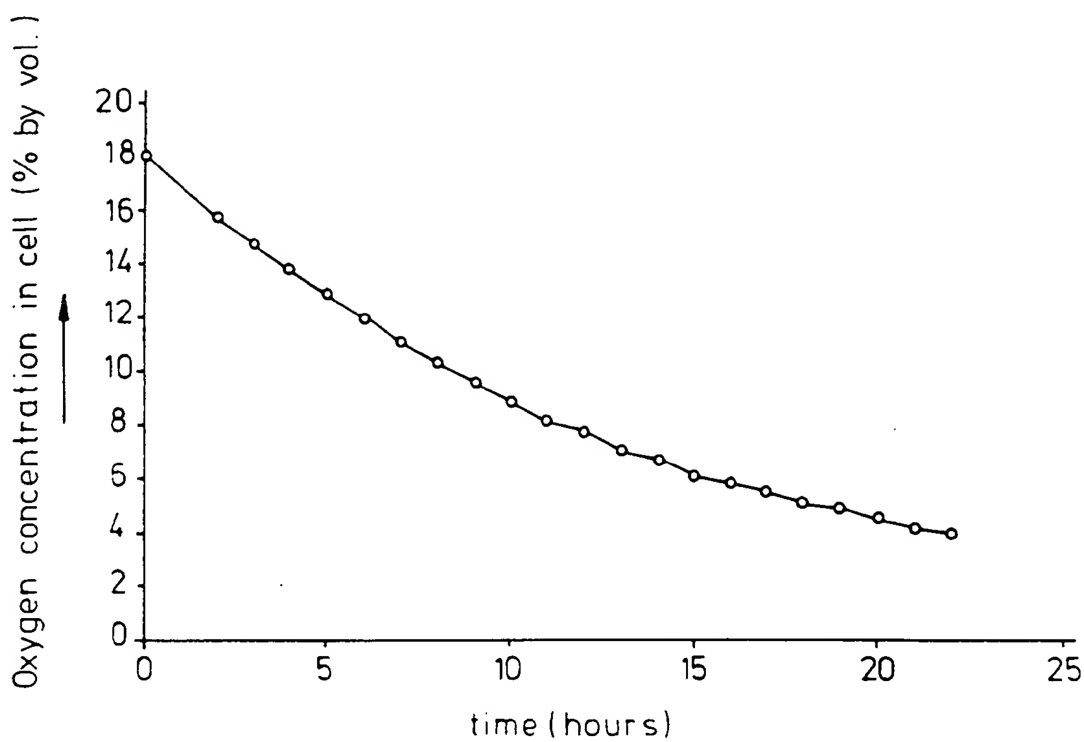

CO_2 concentration in cell (% by vol)
0
1
2
3
4
5
0
4
8
12
16
20
time (hours)

Fig-3


Oxygen concentration in cell (% by vol.)
20
18
16
14
12
10
8
6
4
2
0
0
5
10
15
20
25
time (hours)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 20 0035

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y X	FR-A-2 521 402 (V. P. BELYAKOV ET AL.) * page 4, line 22 - page 5, line 11; figures 2,3 * * page 3, line 19 *	1-4 5	A23B7/148 A23B4/16 A23L3/3418 B01D53/22
Y	EP-A-0 413 621 (F. X. BARBIER) * page 3, line 39 - page 4, line 17; figure 1; example 1 *	1-4	
A	FR-A-1 590 579 (SOC. INDUSTRIELLE DE FILTRATION)		
A	EP-A-0 315 309 (E. ROE ET AL.)		
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 451 (C-643)11 October 1989 & JP-A-1 174 366 (AISIN SEIKI) 10 July 1989		
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 480 (C-771)19 October 1990 & JP-A-2 200 144 (TEIJIN) 8 August 1990		TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 205 (C-595)15 May 1989 & JP-A-1 023 846 (MITSUBISHI) 26 January 1989		A23L A23B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 APRIL 1993	GUYON R.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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